

# Omega and NIF Target Campaigns at LANL

20<sup>th</sup> Target Fabrication Meeting

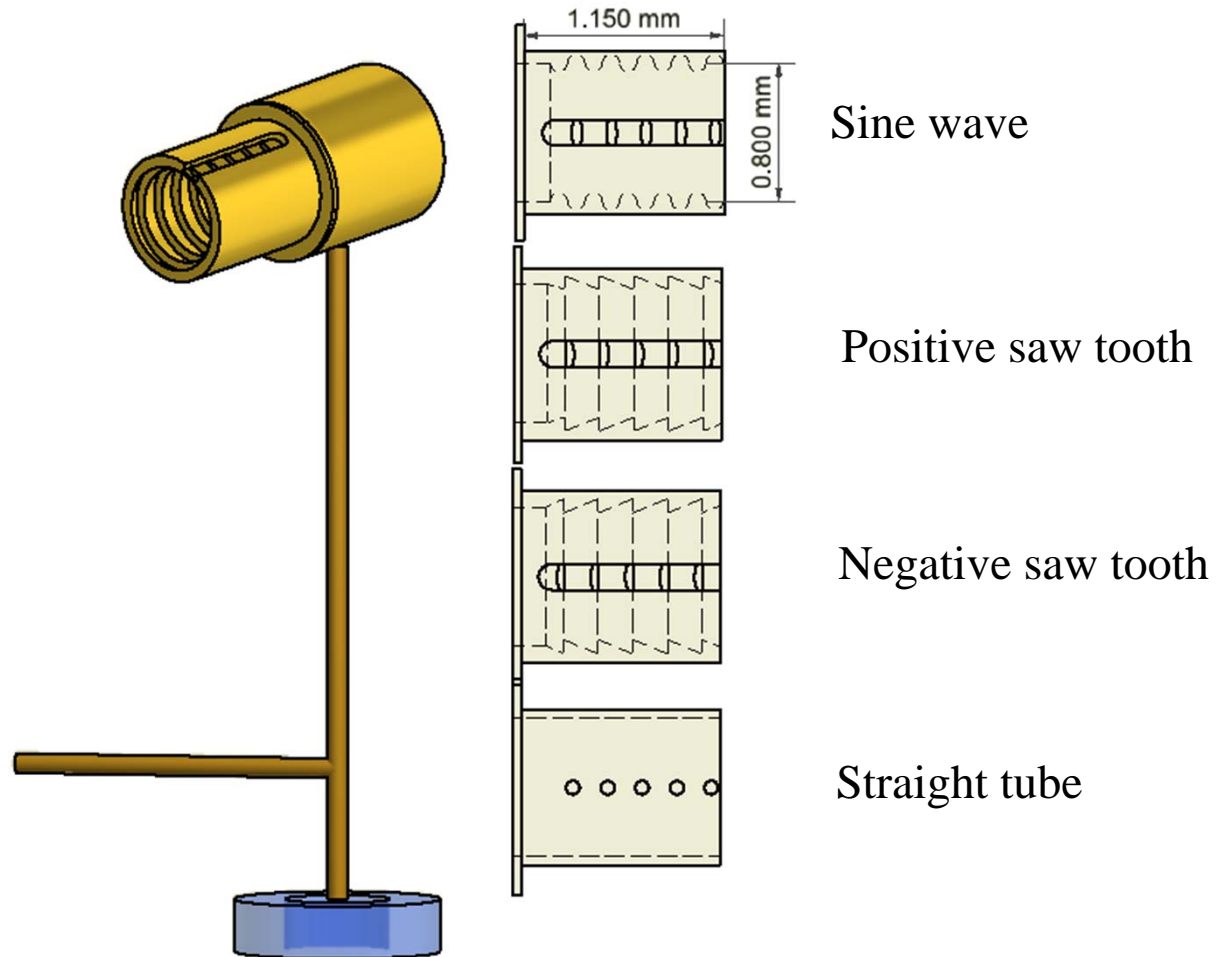
May 21-24, 2012

-Derek Schmidt, Team Leader for Target Fabrication and Machining, Campaign Engineer

- D. Capelli, K. Defriend Obrey, D.J. Devlin, F. Fierro, C.E. Hamilton, J.I. Martinez, B.M. Patterson, R.B. Randolph, G. Rivera, R.J. Sanchez, J.R. Williams -LANL
- R. Wallace -LLNL
- E. Giraldez, A. Greenwood, M. Hoppe, A. Nikroo, B. Vermillion, ...all the hard workers behind the scenes. -General Atomics
- J. Fooks -@LLE
- R. Perea, N. Petta -Schafer

## NIF-5, Series 2 – Two Omega Campaigns

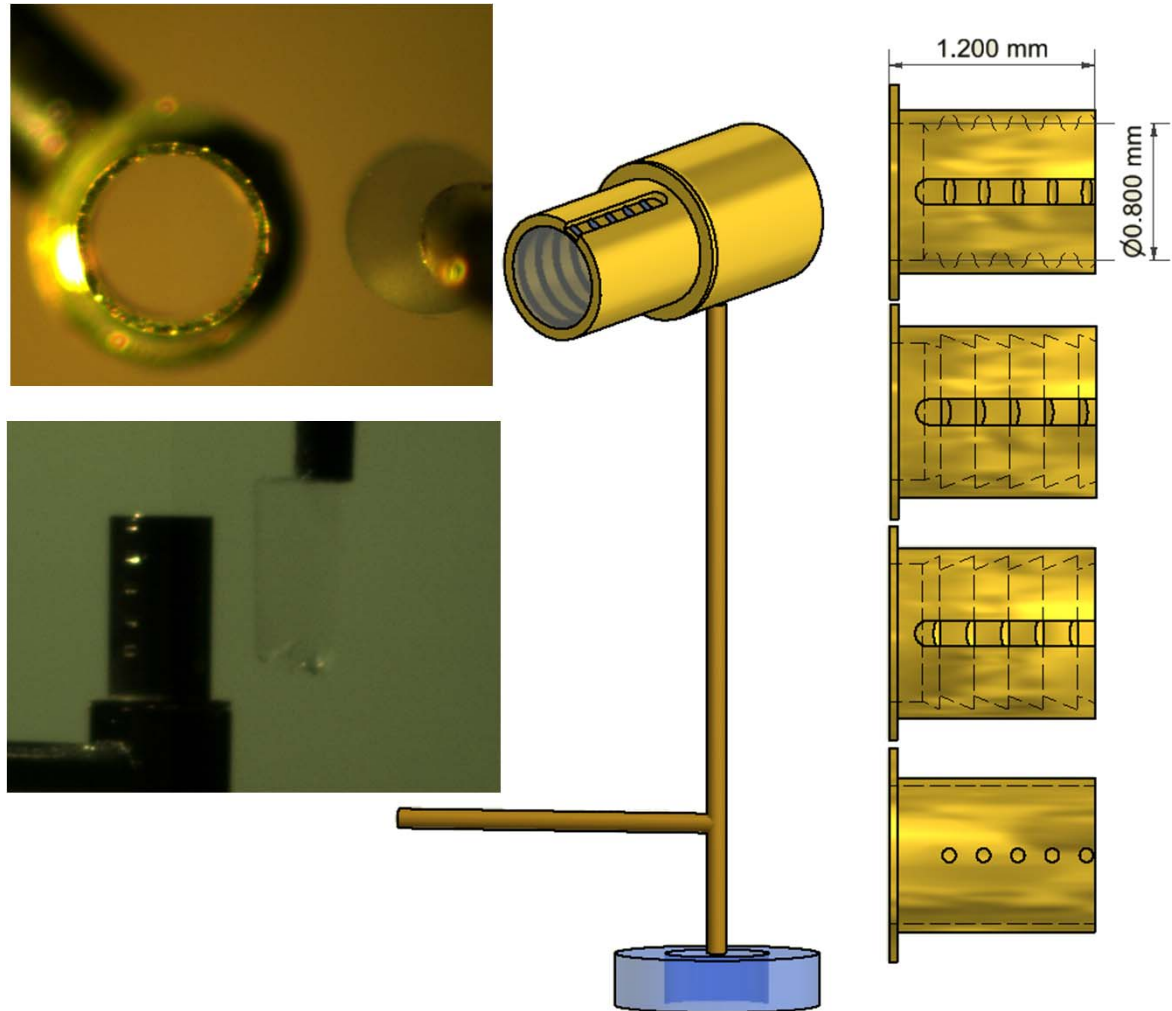
- Study of radiation flow down different tube structures with  $\text{SiO}_2$  aerogel at different densities.
  - 22, 29, 30, 40mg/cc
- Straight tube geometry used to compare machined vs. molded aerogels from the same density and batch.



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# NIF-5, Series 2 – Machining Low Density Aerogels

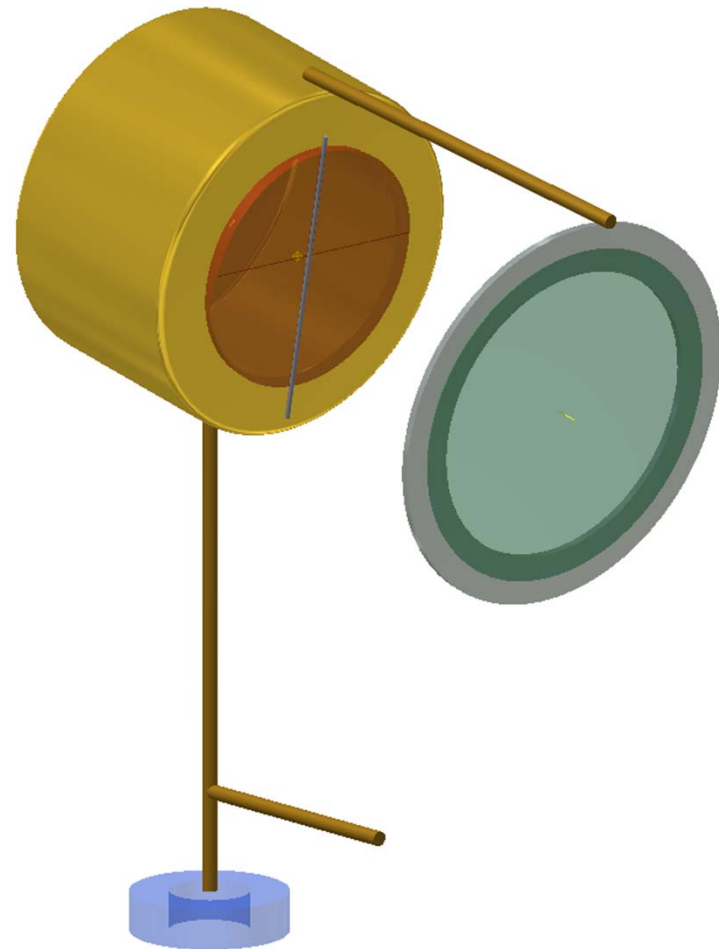
- Machined straight cylinders of  $\text{SiO}_2$  at densities of 22 and 29mg/cc.
- Very different cutting properties between the 22 and 29mg/cc.
- Machining did succeed, handling and robotic handling was responsible for yield issues.
- $R_a=3.0\mu\text{m}$



## CHARM – Three Omega Campaigns

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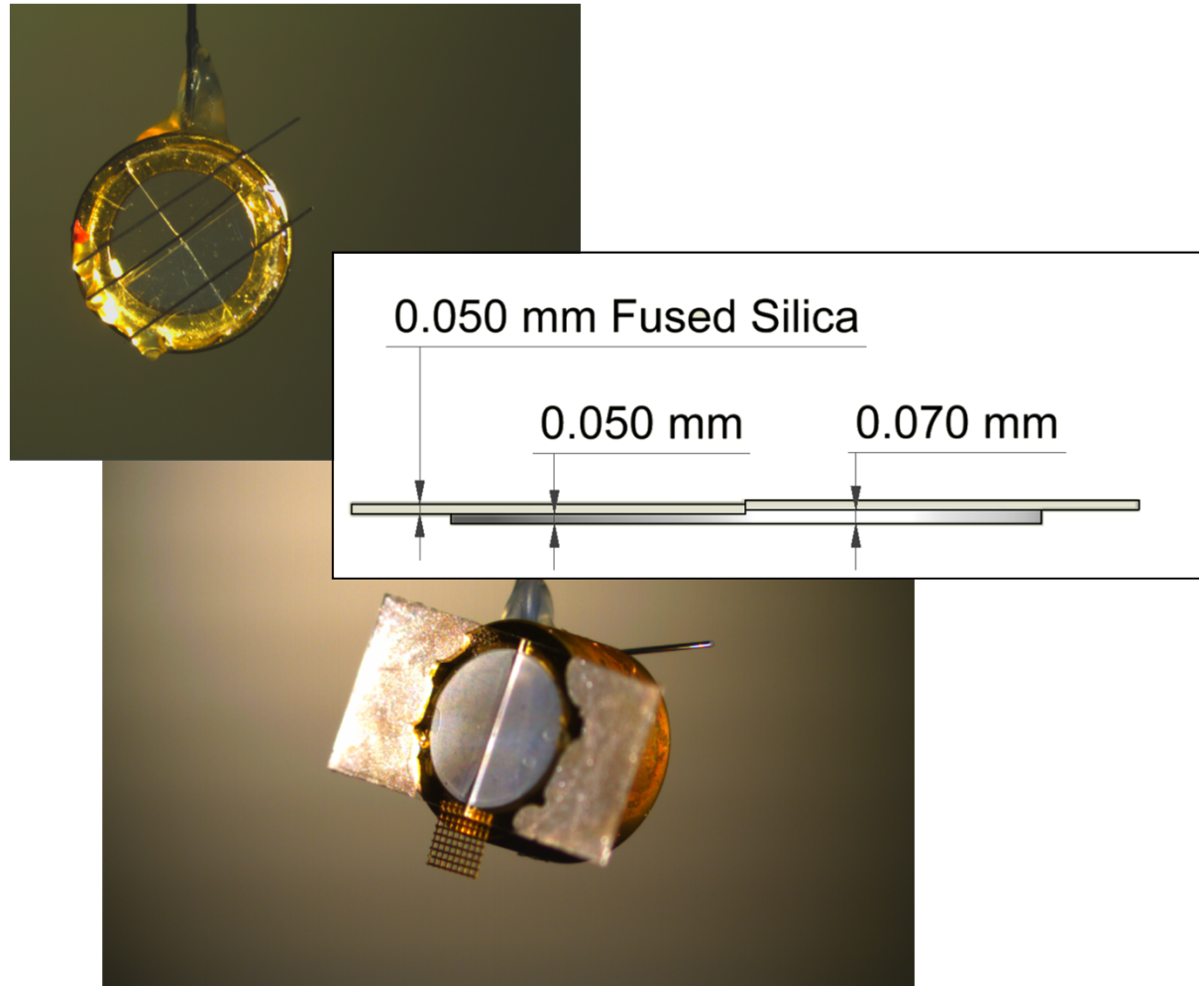
- Targets with features of steps, bumps, and sine waves with quartz windows and special AR coatings.
- General Atomics produced most of the step target packages and all of the bump packages, as well as sine wave beryllium target packages.





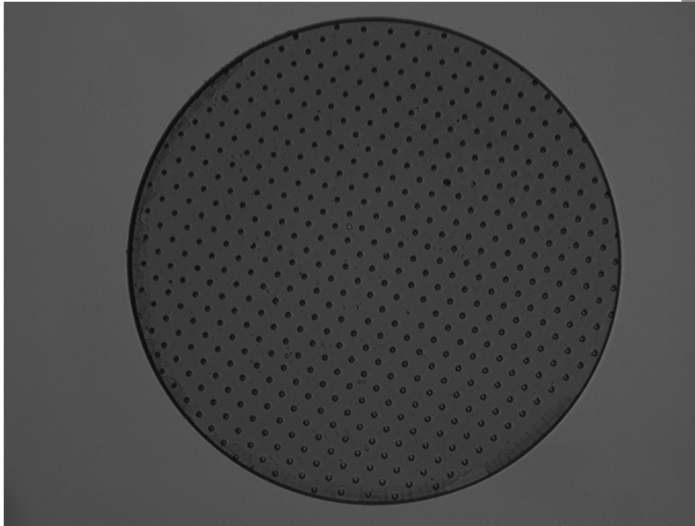
# CHARM-Step Target Designs

- LANL made quadrant steps of thicknesses of 100, 125, 135, and 145 $\mu\text{m}$ .
- GA Machined off axis steps two steps thicknesses of 50/70 $\mu\text{m}$  and 100/125 $\mu\text{m}$ , and a four step target with 50/60/80/90 $\mu\text{m}$  steps
- Step variations with and without aluminum coatings, fused silica 50 $\mu\text{m}$  windows, and anti-reflective coatings.



## CHARM-Bump Target Designs

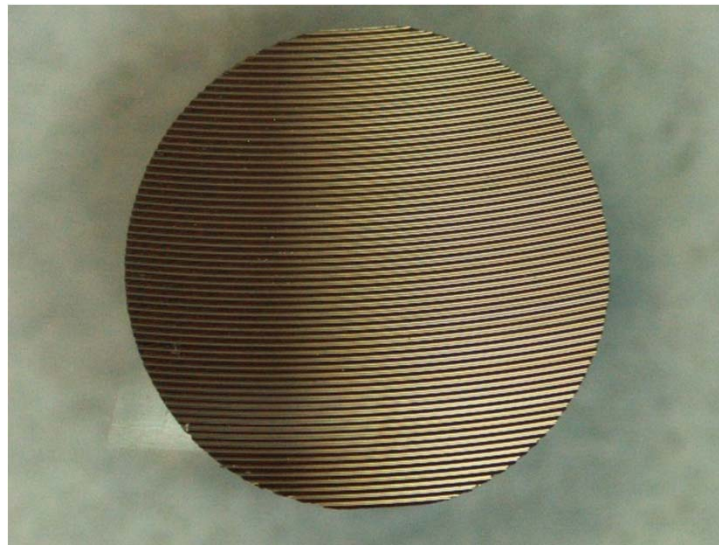
- Array of Gaussian profile bumps of heights from 5 $\mu$ m, 7 $\mu$ m, and 12 $\mu$ m high bumps. Used a masking technique to deposit the bump profile.
- Produced by General Atomics.



## BeARM-Beryllium Sine Waves

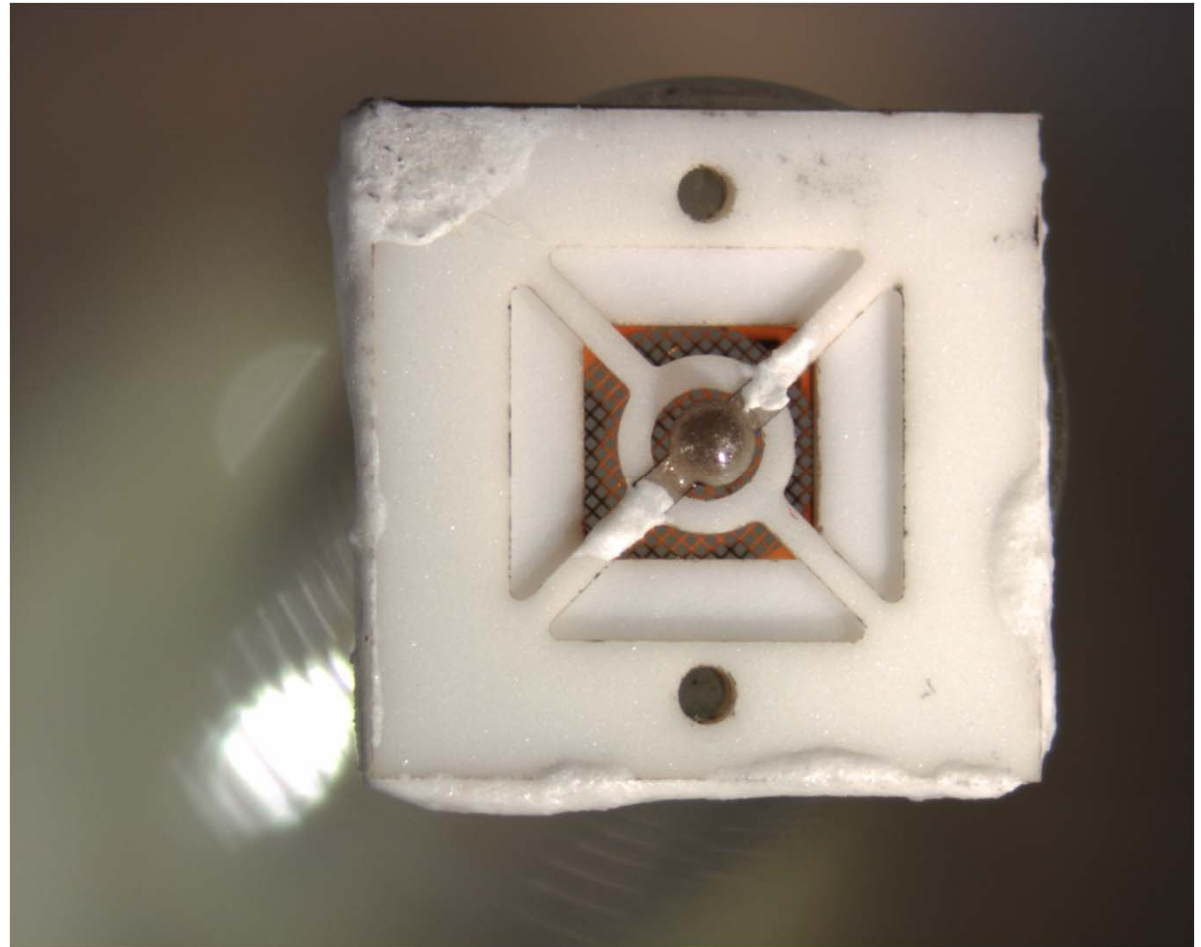
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- Beryllium 4um amplitude, 40um wavelength sine waves with a thickness of 60um.
- Machined off axis and provided by General Atomics



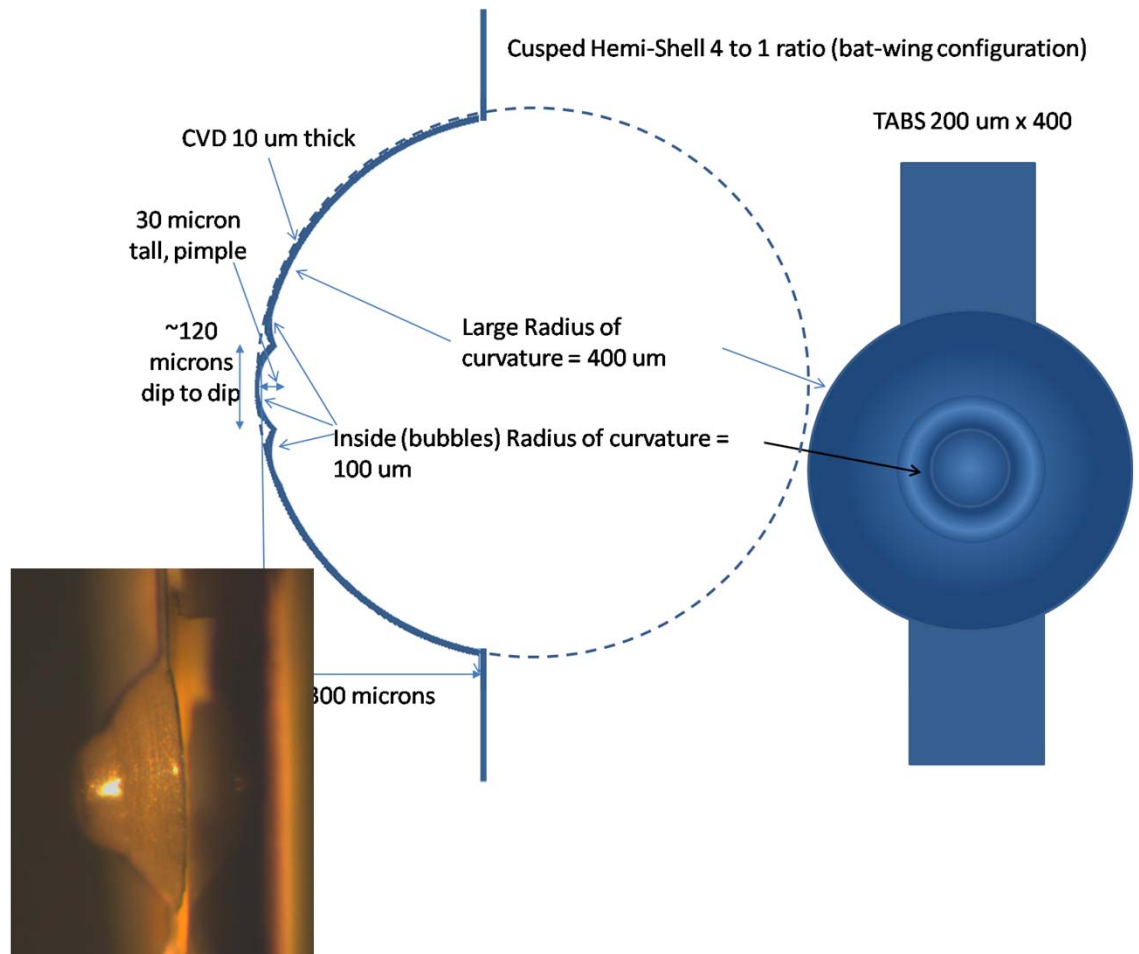
## EP-Focused Ion

- Target is heated to 400°C with a laser inserted into one port of the EP/Trident chamber before the main beams are put onto the diamond hemi shell.
- Alumina spacers and ceramic high temperature glues are used to withstand the high temperatures.



## EP-Focused Ion

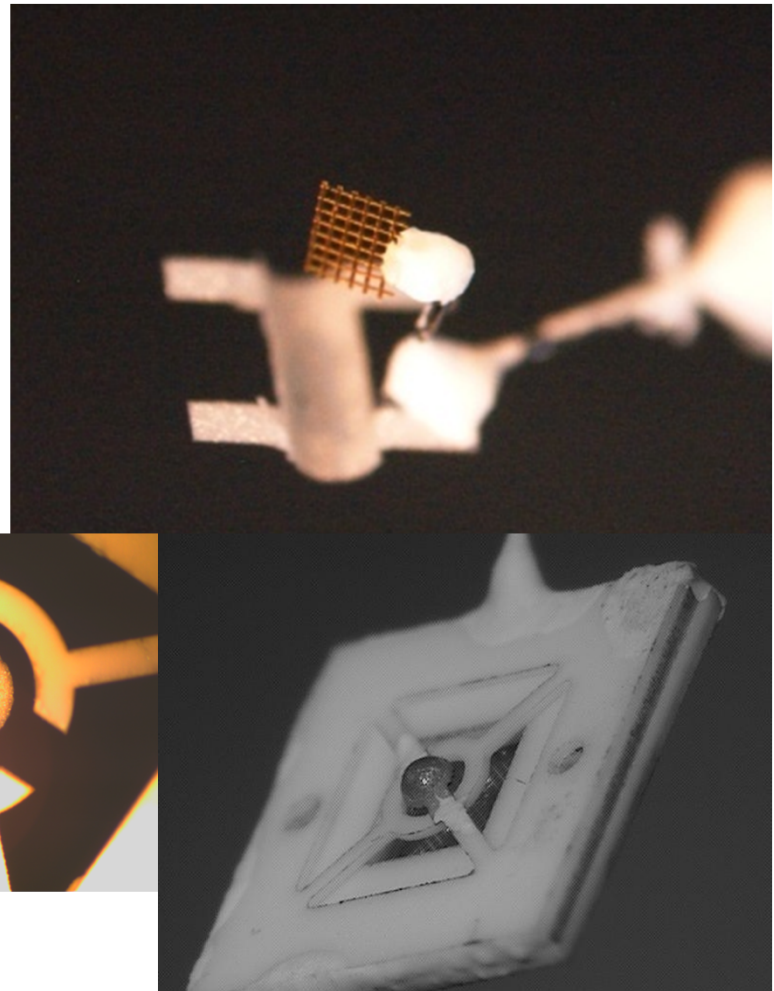
- Unique profiles for the creation of the focused ion experiment.
  - Cylinder drive targets with free standing grids offset.
  - Dual stage curved hemi's with specified profiles to create a dual stage ion flux.
- Spherical and unique non-spherical profiles were used to optimize the ion focusing produced by the heated diamond.
- Diamond coatings purchased from external vendor.





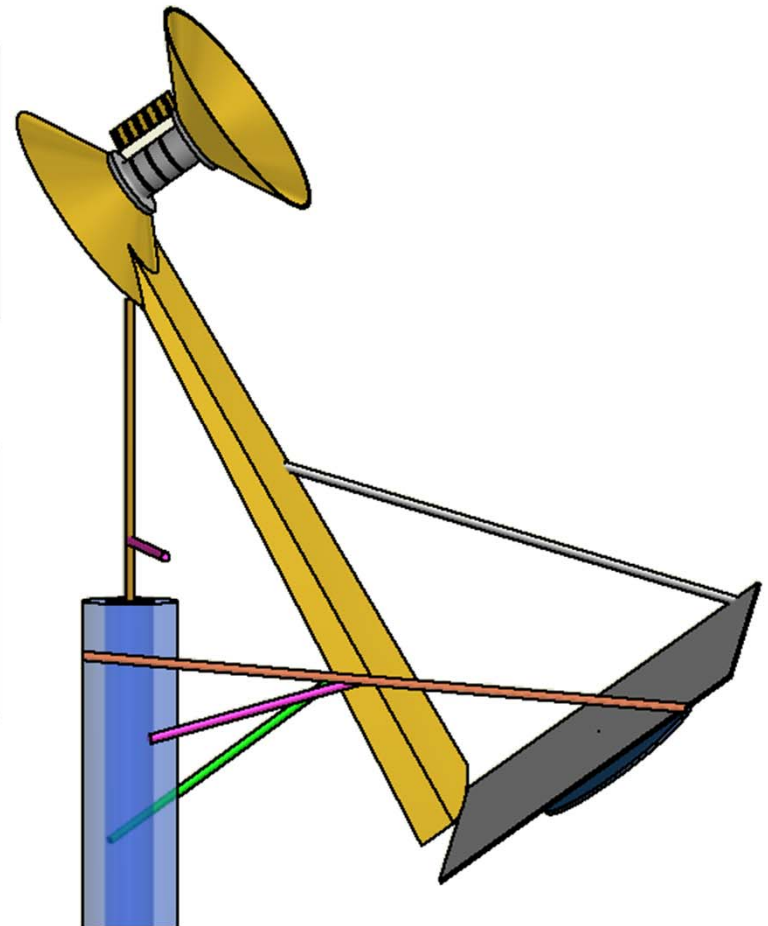
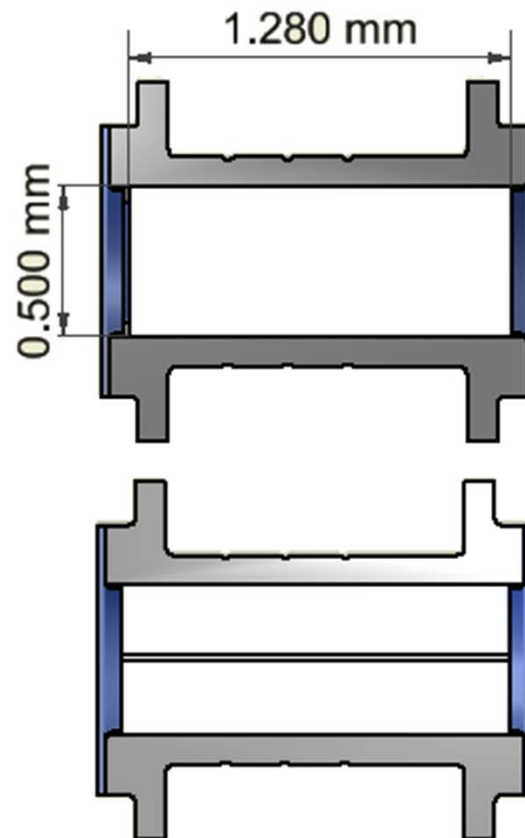
## EP-Focused Ion

- Micro-dots of ceramic glue that bond and hold the components in the freestanding case was very troublesome.
- High temperature ceramic glues with 24 hour curing times cured almost instantly once it was pulled out of the bulk to be used as a micro-glue dot.
  - Attempts to dilute with many solvents failed.
- High temperature 'paint' was also tried and failed.



# Shear / Colliding Shock – Eight Shot Days

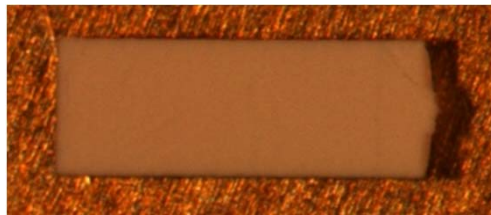
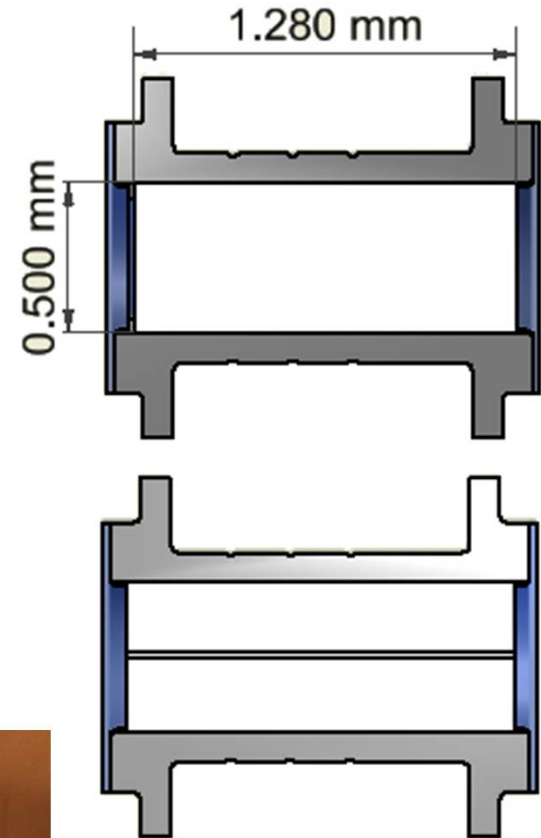
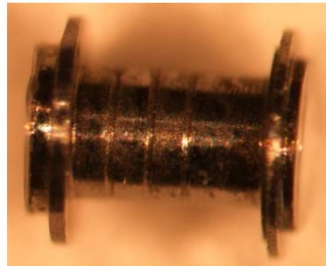
- Two Design Platforms
  - Beryllium tube with dual end caps on either ends.
  - Colliding Shock is a solid CH foam inserted with an endcap of 20um PVD coated Al.
  - Shear is a split CH foam with a 20um aluminum coating down the length of the tube.





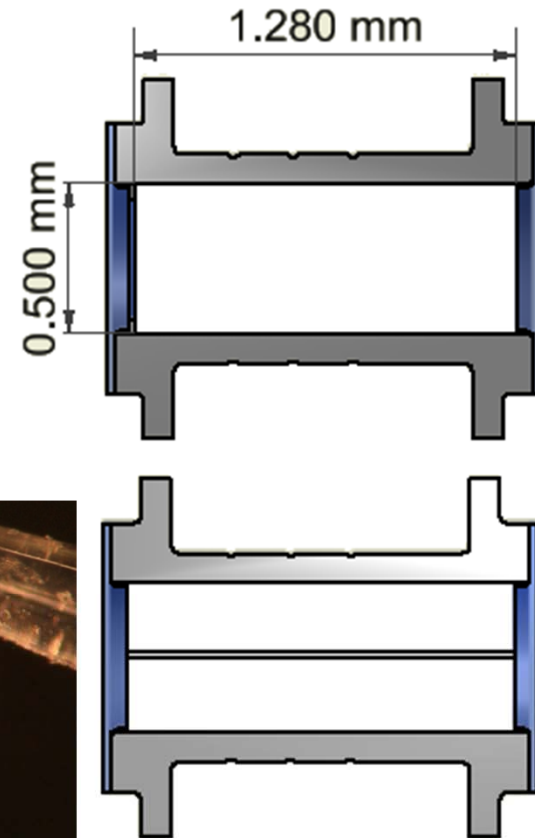
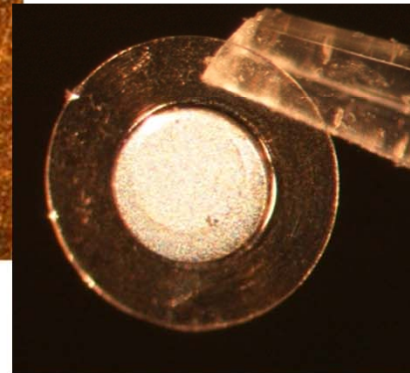
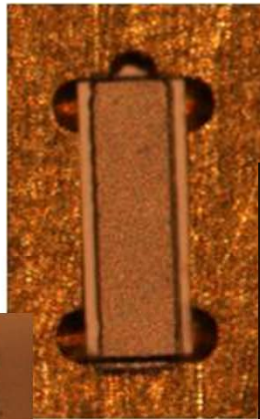
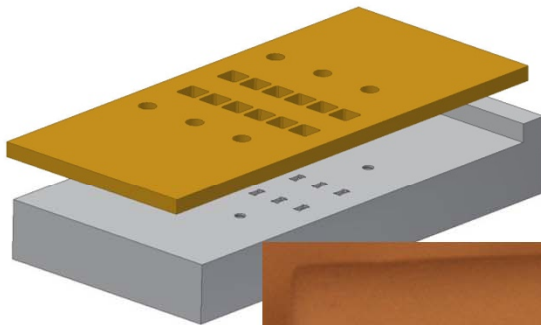
# Shear / Colliding Shock – Challenging Fabrication

- Very small beryllium components.
  - 500um inner diameter with indicating grooves on the side of the tube.
  - New design with a length of 1.6mm.
- The experiment required density ranges of 60 and 375mg/cc of both CH and CH-Cl foams. Foam production is on average 200-240 foam parts for one campaign to address yield issues due to catalyst formation and small imperfections, all machined in 5-7 days.



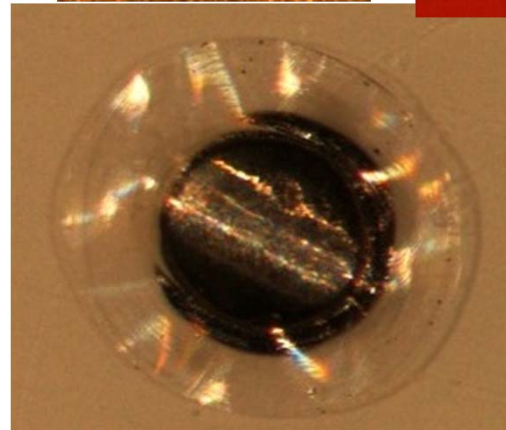
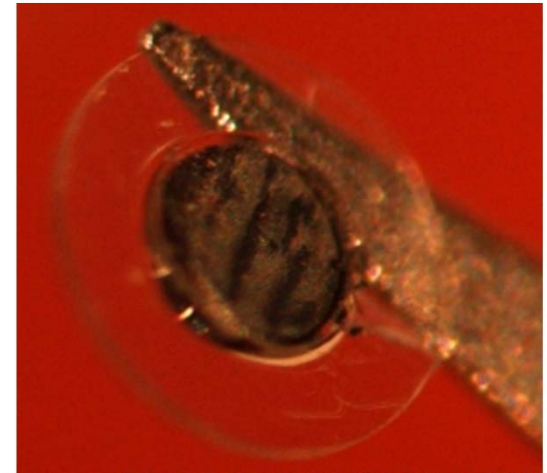
## Shear / Colliding Shock – Coating Challenges

- Target design requires a 20um thick PVD coating of aluminum/titanium onto one half of the split foam. Special masks had to be designed to only coat down the central 400um's of the 500um width for the split foams, and only on a central 400um diameter on the colliding shock targets.



## Shear/CS-Coating Hurdles Al/Ti

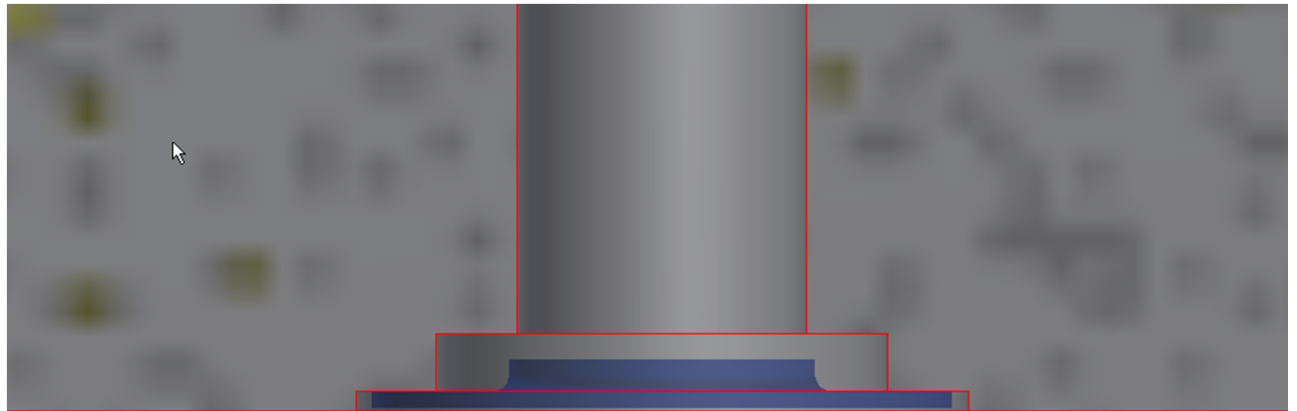
- Stories of Development
- Some yield loss from simple e-beam realities.
- Titanium deposition caused the greatest problems.
  - E-beam produced a film so strained it was buckling.
  - Sputtering at elevated substrate temperatures melted the rexolite.



## Shear/CS – Coating Fixture Design

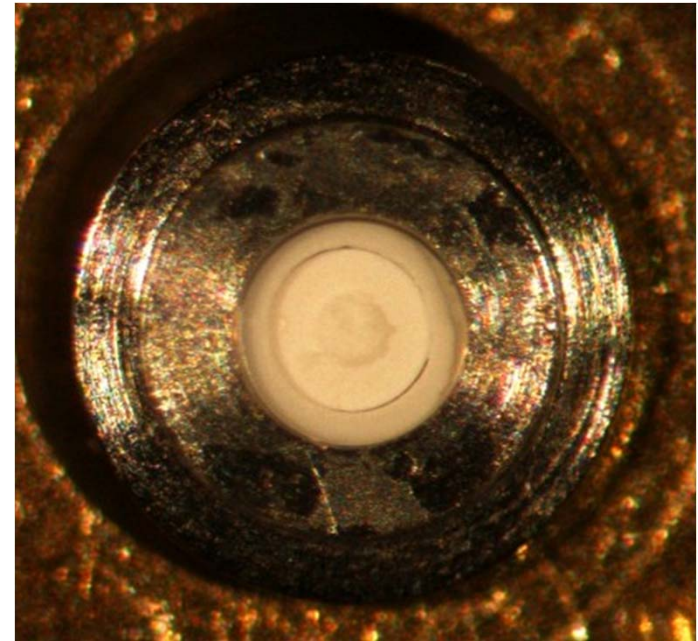
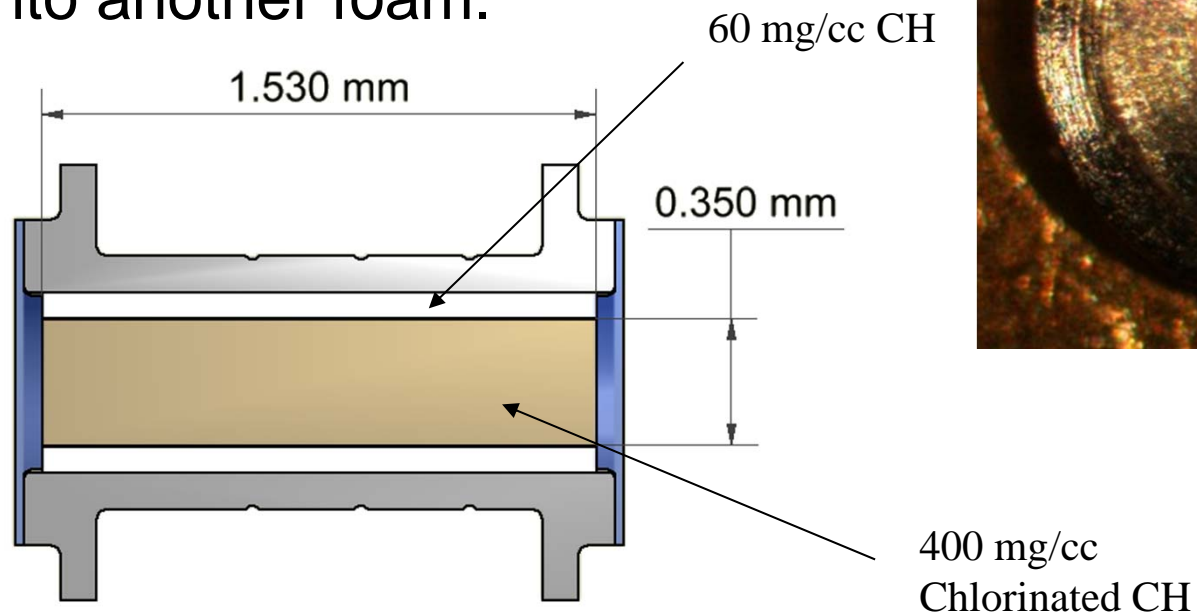
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- Simple geometry fixed one of our repeat offenders.



## Shear – Concentric Cylinders

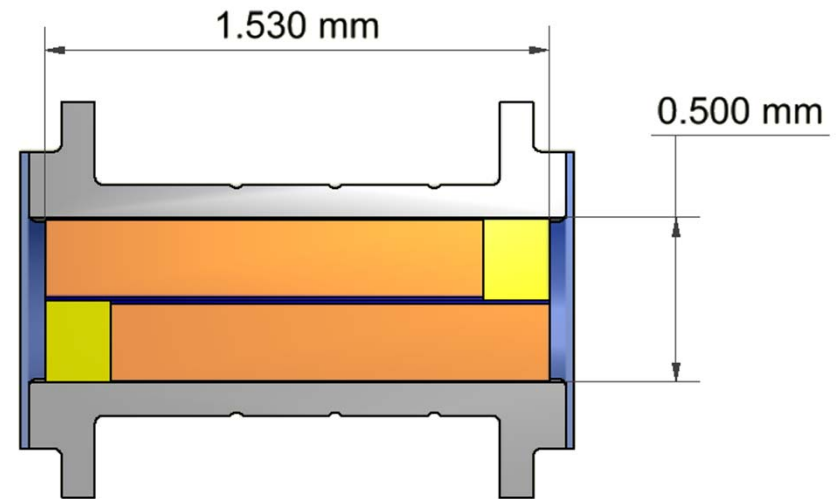
- Longer geometry design with one foam type machined to insert into another foam.



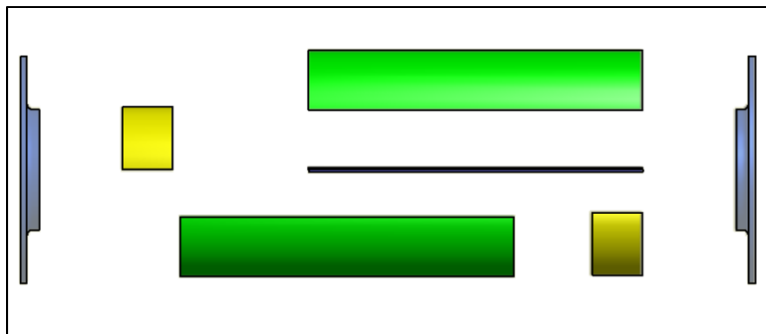


# Shear – New Challenging Multi-Internal Component Assembly

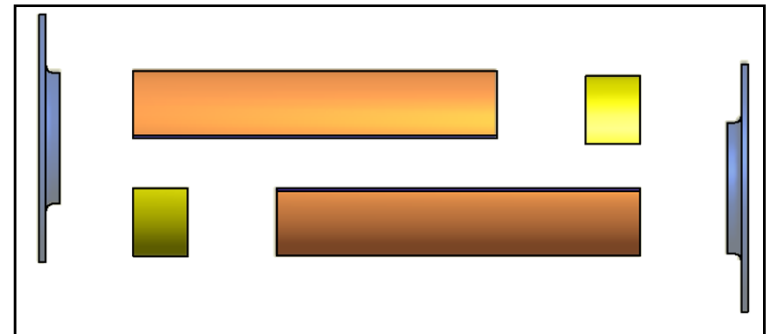
- Counter-propagating Shear Design.
- How to assemble up to 5 internal delicate structures at once into a very small tube?



Aluminum Foil Design

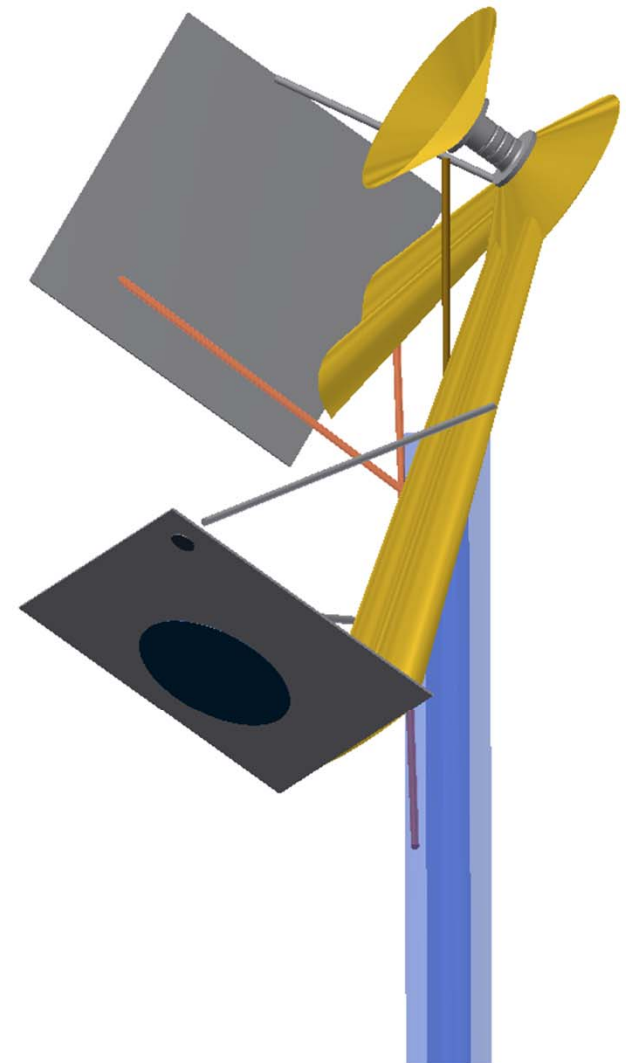
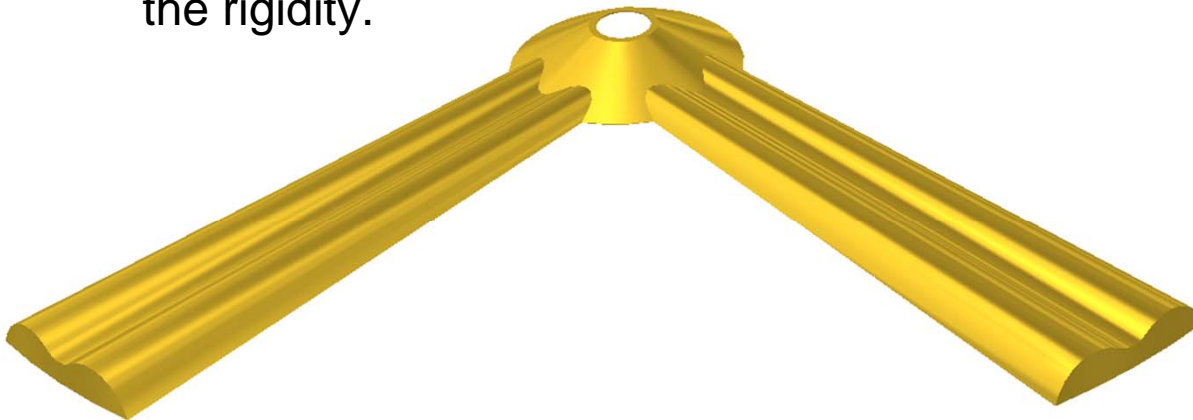


Aluminum Coating Design



## Shear / Colliding Shock – Geometry Challenges

- Dual-axis design over 12mm distances from the pinholes to the beryllium target in the middle to reduce the alignment time of a three independent target design.
- Rigidity considerations for a dual wing structure to fully support the target through handling and transportation. Addition of many trusses to help the rigidity.





# ABEX – Sine Wave Capsules

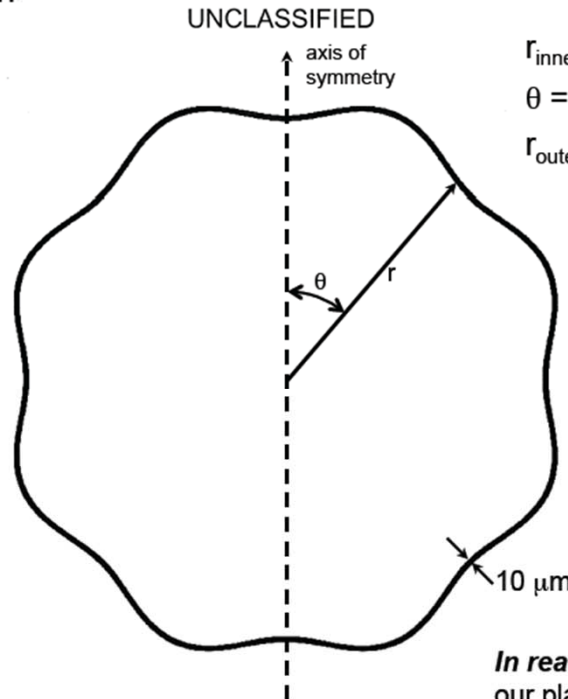
ICF perturbed capsule  
“200%” version

An initial trial build  
could aim for:

$$r_{\text{inner}}^0 = \sim 430 \mu\text{m}$$

$$\Delta r = \sim 15 \mu\text{m}$$

$$\Delta r_{\text{wall}} = \sim 15 \mu\text{m}$$



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axis of  
symmetry

$$r_{\text{inner}} = r_{\text{inner}}^0 - \Delta r \cos[8\theta]$$

$$\theta = 0 \text{ to } \pi$$

$$r_{\text{outer}} = r_{\text{inner}} + \Delta r_{\text{wall}}$$

**as drawn:**

$$r_{\text{inner}}^0 = 427.5 \mu\text{m}$$

$$\Delta r = 20 \mu\text{m}$$

$$\Delta r_{\text{wall}} = 10 \mu\text{m}$$

so:

$$407.5 \mu\text{m} \leq r_{\text{inner}} \leq 447.5 \mu\text{m}$$

$$417.5 \mu\text{m} \leq r_{\text{outer}} \leq 457.5 \mu\text{m}$$

**In reality**,  $\Delta r_{\text{wall}} = 10 \mu\text{m}$  is too thin for  
our plans.

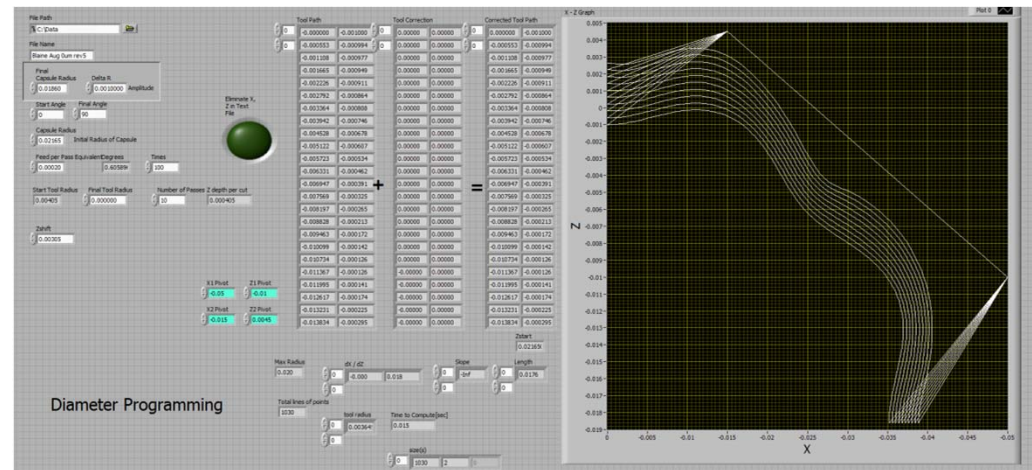
A wall-thickness of 13-15  $\mu\text{m}$  is more  
suitable for initial experiments, perhaps  
increasing to  $\sim 30 \mu\text{m}$  further on.

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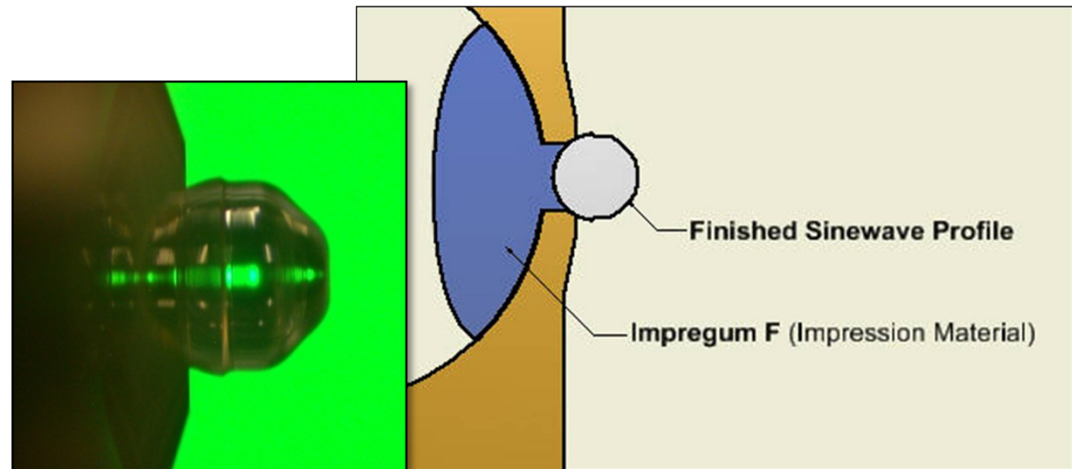
F. J. Wysocki, E. S. Dodd  
Feb. 19, 2010

# ABEX – Sine Wave Capsules Mandrel Production

- Challenge of having to write our own machining programs to increment in both X and Z to bring in the profile.



- Many details and challenges of machining one side of a profile and flipping the mandrel to machine the backside profile to match each other.

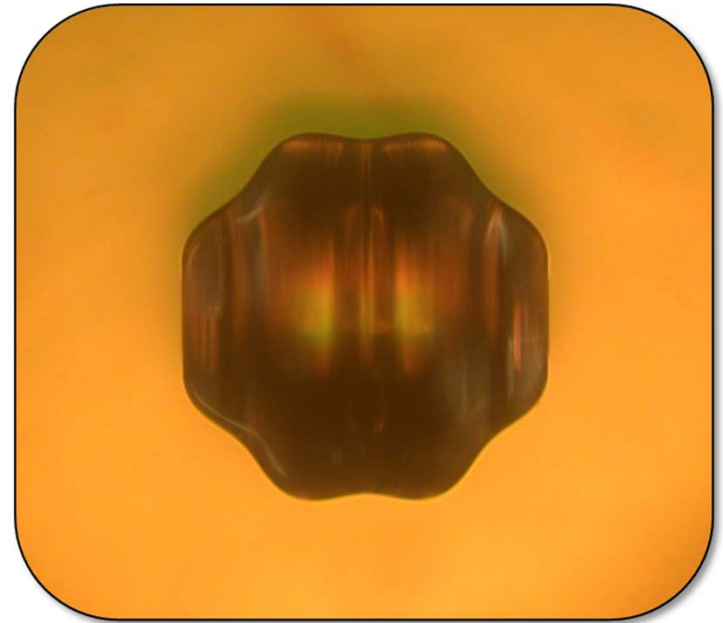


\*Poster by Blaine Randolph, Tuesday Night

## ABEX – Sine Wave Capsules

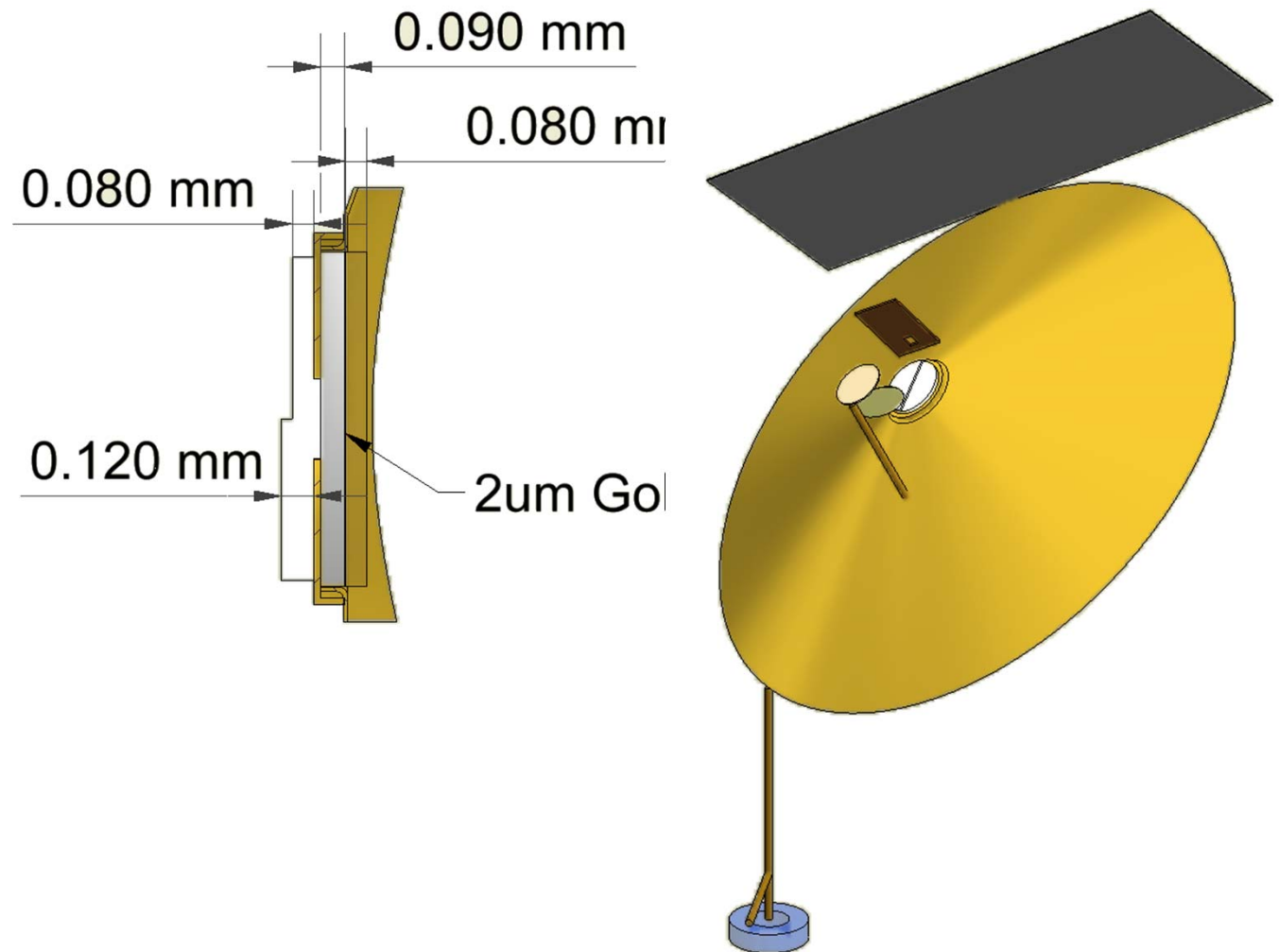
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- Radial amplitude sine waves of 2.5um, 5um, 10um, 15um, and 20um were all produced successfully.
- The first round of targets did show only a 1-2um difference in the profiles, the second round of targets did incorporate new improvements in the process to fix this relatively small issue.
- Outstanding effort by GA in the design meetings, characterization, and doing test runs ahead of time to test the theory of removing a full PAMS solid bead.



## DP-EOS

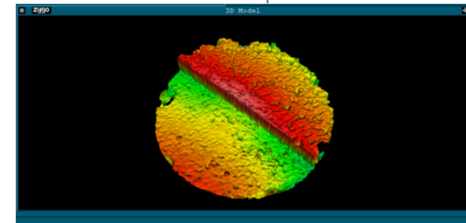
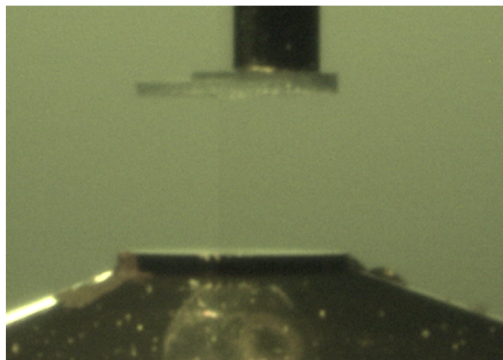
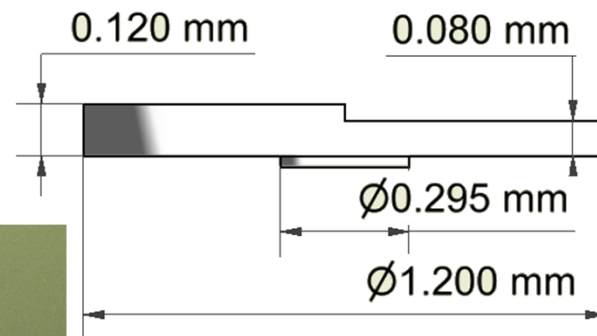
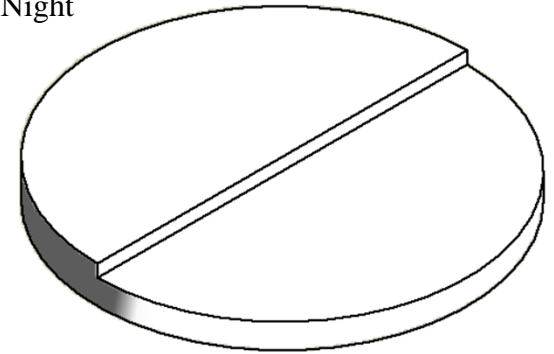
- Rear sandwich consists of polystyrene ablator, 2 $\mu$ m Gold, and an aluminum foil.
- Extremely thin aerogel step requested of a density of 200 mg/cc.



# DP-EOS – Challenging Aerogel Milling

\*Poster by Frank Fierro, Tuesday Night

- First time we have ever milled an aerogel, and definitely a challenge at this thickness.
- 200mg/cc  $\text{SiO}_2$  aerogel.
- Some aerogels were then coated with aluminum to help with the reflective aspects of the SOP/VISAR measurement for the experiment.

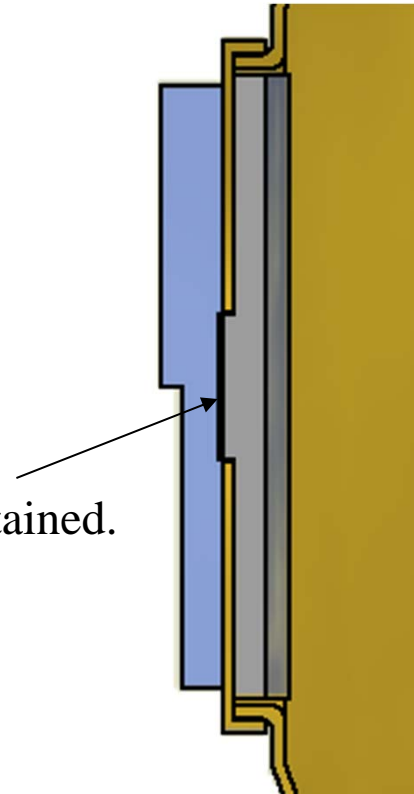


## DP-EOS – Redesign

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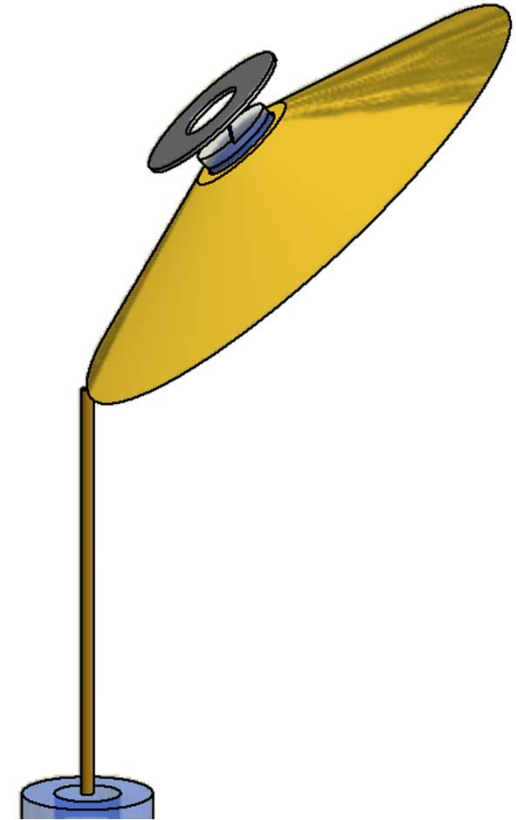
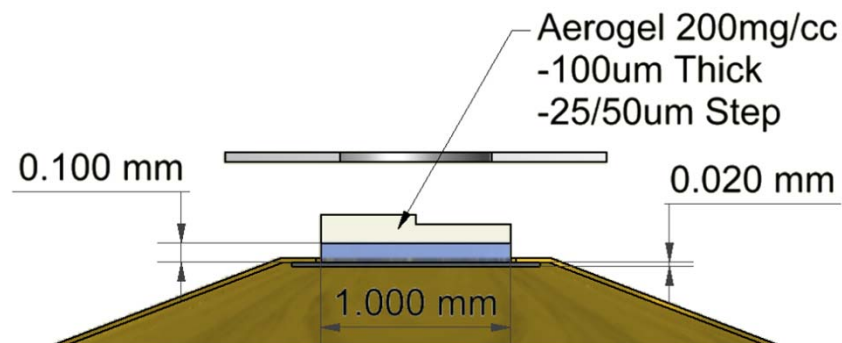
- Eliminated the nub from the aerogel to the aluminum where it could be more easily machined with greater confidence.
- WLI to prove the aluminum protruded above the gold wing and made contact with the aerogel.

Aluminum 90um overall thickness maintained.



## NIF-5 Redesign for Aerogel EOS Application

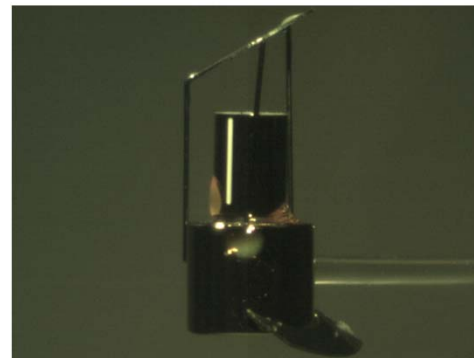
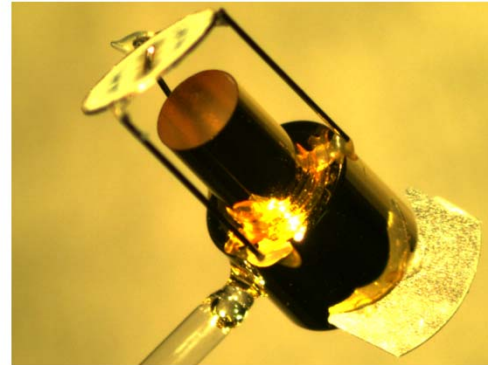
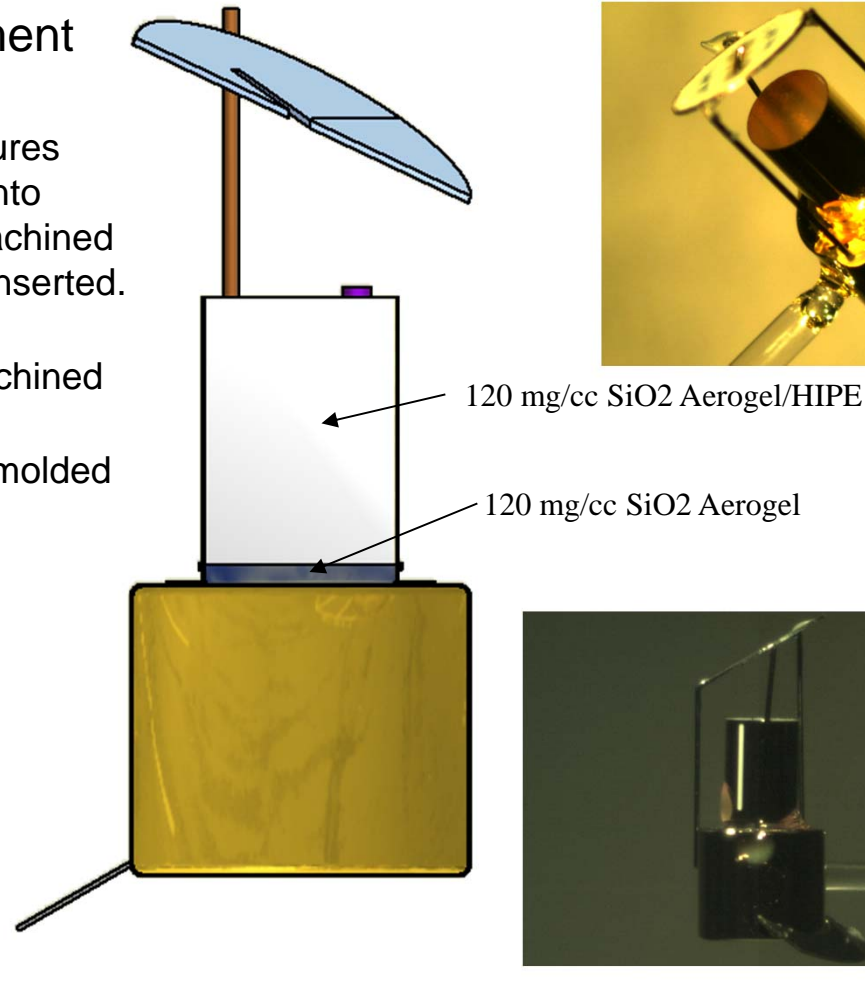
- Even more challenging milling of Aerogel Step Features at remarkably small sizes.





# NIF Pleiades Campaign June 2010-August 2012

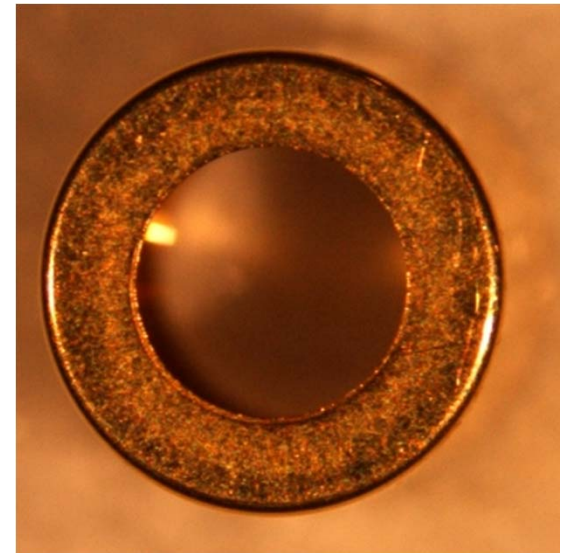
- Platform Development Target
  - Aerogel cast in fixtures and then inserted into longer tubes, or machined by AWE and then inserted.
  - HIPE foams fully formulated and machined by AWE
  - Aerogel “Top Hat” molded in place by LANL.



## NIF Pleiades

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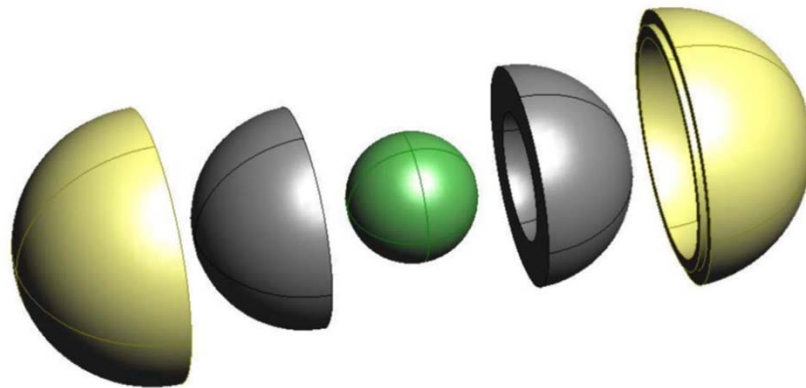
- Very high quality foam production by AWE and LANL.
- New Density Characterization System (DCS) designed to measure the 2D density uniformity of the foams using a monochromatic x-ray source.



## Double-Shell Robot Developed

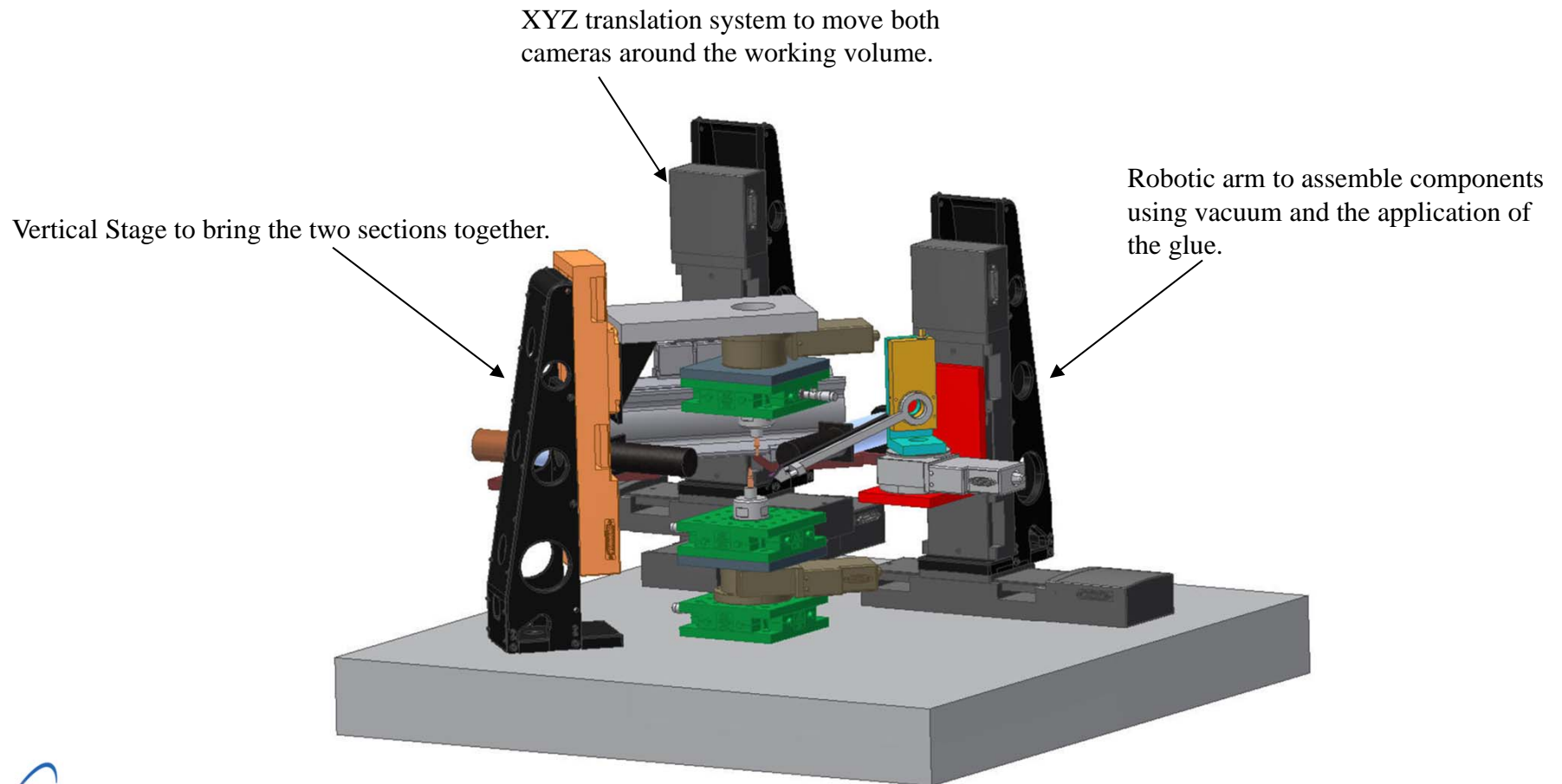
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- Proof-of-principle to be able to make the “LLNL design” of a double shell target that goes through the machining of the outer shells, adhesion of the two outer shells with Epon, the successful assembly using the robot, and the final machining of double shells.



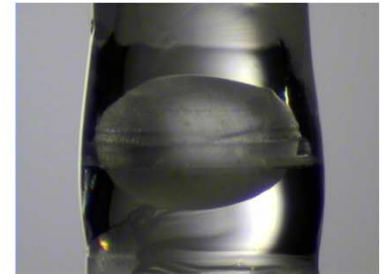
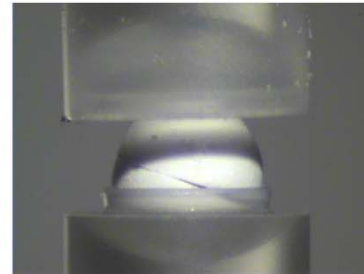
# Double-Shell Robot Overview

\*Poster by Jim Williams, Tuesday Night



## Double-Shell Stages of Assembly on the Robot

- Assembly of inner package of surrogate capsule with two outer foams into the bottom shell.
- Aligning of the two machined shells using the dual optical axis.
- Gluing of the shells.
- After the first machining step of the final profile.



\*Poster by Jim Williams, Tuesday Night

# Successful Teamwork

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- D. Schmidt, D. Capelli, K. Defriend Obrey, D.J. Devlin, F. Fierro, C.E. Hamilton, J.I. Martinez, B.M. Patterson, R.B. Randolph, G. Rivera, R.J. Sanchez, J.R. Williams  
-LANL
- R. Wallace -LLNL
- E. Giraldez, A. Greenwood, M. Hoppe, A. Nikroo, B. Vermillion, ... everybody else  
behind the scenes. -General Atomics
- J. Fooks -@LLE
- R. Perea, N. Petta -Schafer